PART 1

1.) Estimate Autoregressive Integrated Moving Average (ARIMA(p,d,q)) model for spot and future – determine the most appropriated order for p, d, and q using SBIC given the maximum lag equals 4.

```
. tsset time
        time variable:  time, 1 to 795
                delta:  1 unit

. g y = spot *set spot value as y in order to use do file easier"
. do "/var/folders/qx/mw3zz03s545c66rmml_hrzfc0000gn/T//SD16322.000000"

. forvalues p = 1(1)4{
  2. forvalues q = 1(1)4{
  3.                 display " estimate arima`p'1`q'"
  4.                 qui arima y, arima(`p',1,`q') nolog
  5.                 est store arima`p'1`q'
  6. }
  7. }
 estimate arima111
 estimate arima112
 estimate arima113
 estimate arima114
 estimate arima211
 estimate arima212
 estimate arima213
 estimate arima214
 estimate arima311
 estimate arima312
 estimate arima313
 estimate arima314
 estimate arima411
 estimate arima412
 estimate arima413
 estimate arima414

.
end of do-file

. est table arima11*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)

----------------------------------------------------------------------------
    Variable |   arima111        arima112        arima113        arima114
-------------+--------------------------------------------------------------
y            |
       _cons | -.10471744      -.10468155      -.10474014      -.10717398
-------------+--------------------------------------------------------------
ARMA         |
          ar |
         L1. |  .43536547*      .32884791      -.21609401       .59490084
             |
          ma |
         L1. | -.35351081      -.25287121       .29330109      -.52209152
         L2. |                  .02661686       .06275321      -.00167449
         L3. |                                  .07084457**     .03360908
         L4. |                                                 -.07201064*
-------------+--------------------------------------------------------------
sigma        |
       _cons |  8.1399985***    8.1383248***    8.1283318***    8.1204174***
-------------+--------------------------------------------------------------
Statistics   |
           N |        794             794             794             794
          ll | -2791.4965      -2791.3458      -2790.3816      -2789.5823
        chi2 |  18.312657        16.97941        13.218602       28.319443
         aic |   5590.993       5592.6915       5592.7633       5593.1646
         bic |   5609.7013       5616.077       5620.8258       5625.9042
----------------------------------------------------------------------------
                                        legend: * p<.1; ** p<.05; *** p<.01

. est table arima21*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)
```

Variable	arima211	arima212	arima213	arima214
y				
_cons	-.10453586	-.10767542	-.10609456	-.10747347
ARMA				
ar				
L1.	.30210361	1.3247307***	.46523894***	1.3085163***
L2.	.02452891	-.92390998***	-.83397031***	-.92906275***
ma				
L1.	-.22494448	-1.3022249***	-.39216993***	-1.2433923***
L2.		.94779741***	.82697929***	.88679293***
L3.			.09595475***	.05677728
L4.				.00003472
sigma				
_cons	8.1387104***	8.077039***	8.1149358***	8.0663508***
Statistics				
N	794	794	794	794
ll	-2791.3835	-2785.5252	-2789.1057	-2784.5179
chi2	16.085901	3656.4671	241.72156	4791.7034
aic	5592.7671	5583.0504	5592.2113	5585.0358
bic	5616.1525	5611.1129	5624.9509	5622.4524

legend: * p<.1; ** p<.05; *** p<.01

```
. est table arima31*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)
```

Variable	arima311	arima312	arima313	arima314
y				
_cons	-.10486338	-.10606433	-.10806841	-.10765208
ARMA				
ar				
L1.	-.56058829	.56814277***	.66749387**	.58444954
L2.	.08569307*	-.89762847***	-.06995188	.02671133
L3.	.06374492**	.09752317***	-.59846871*	-.67269654
ma				
L1.	.63856195	-.49161073***	-.61040004*	-.51894361
L2.		.88783708***	.0556601	-.03501301
L3.			.65798111**	.71899187
L4.				.02307553
sigma				
_cons	8.1302906***	8.1136284***	8.0655263***	8.0640794***
Statistics				
N	794	794	794	794
ll	-2790.5308	-2788.9397	-2784.4054	-2784.2793
chi2	21.334447	289.47751	1722.9017	1770.3817
aic	5593.0617	5591.8793	5584.8108	5586.5587
bic	5621.1242	5624.6189	5622.2274	5628.6524

legend: * p<.1; ** p<.05; *** p<.01

```
. est table arima41*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)
```

Variable	arima411	arima412	arima413	arima414
y				
_cons	-.10781888	-.10743716	-.10771017	-.10767653
ARMA				
ar				
L1.	.6019371*	1.3677396***	.61533738	.83865029
L2.	-.00196743	-1.0093746***	.0094391	-.13015924
L3.	.02357655	.05751154	-.67660585	-.67766115
L4.	-.074501**	-.001562	.02303694	.17029234
ma				

```
         L1. | -.52565375       -1.302657***   -.54898831      -.77133898
         L2. |                   .96445922***   -.01948257       .10786573
         L3. |                                   .72230601       .72482037
         L4. |                                                  -.15743316
-------------+----------------------------------------------------------------
sigma        |
       _cons |  8.1178063***     8.066311***    8.0639684***    8.0633837***
-------------+----------------------------------------------------------------
Statistics   |
           N |        794             794             794             794
          ll | -2789.3297      -2784.5185      -2784.2686      -2784.2263
        chi2 |  30.742143       5310.9545       1882.2706       2721.9204
         aic |  5592.6594        5585.037       5586.5371       5588.4525
         bic |   5625.399       5622.4537       5628.6309       5635.2234
------------------------------------------------------------------------------
                                        legend: * p<.1; ** p<.05; *** p<.01
```

for the spot arima(1,1,1) is the most appropriate model since it has the lowest BIC

```
. drop y

. gen y = future *set spot value as y in order to use do file easier"


. do "/Users/jharit/Desktop/arima do file.do"

. forvalues p = 1(1)4{
  2. forvalues q = 1(1)4{
  3.                 display " estimate arima`p'1`q'"
  4.                 qui arima y, arima(`p',1,`q') nolog
  5.                 est store arima`p'1`q'
  6. }
  7. }
 estimate arima111
 estimate arima112
 estimate arima113
 estimate arima114
 estimate arima211
 estimate arima212
 estimate arima213
 estimate arima214
 estimate arima311
 estimate arima312
 estimate arima313
 estimate arima314
 estimate arima411
 estimate arima412
 estimate arima413
 estimate arima414

.
end of do-file

. est table arima11*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)

-------------------------------------------------------------------------------
    Variable |   arima111        arima112        arima113        arima114
-------------+-----------------------------------------------------------------
y            |
       _cons | -.11424575      -.11408115       -.1139183      -.11370744
-------------+-----------------------------------------------------------------
ARMA         |
          ar |
         L1. | -.36850497       .30224152       .07471074      -.26441554
             |
          ma |
         L1. |  .33119538      -.33885872      -.11128313       .23060131
         L2. |                  .04456173        .0345267       .02935071
         L3. |                                  .03319847       .04074154
         L4. |                                                  .03843721
-------------+-----------------------------------------------------------------
sigma        |
       _cons |  9.5427695***    9.5390832***    9.5360585***     9.532552***
-------------+-----------------------------------------------------------------
Statistics   |
```

```
           N |        794             794             794             794
          ll |  -2917.724      -2917.4236       -2917.166      -2916.8767
        chi2 |  3.3320137       3.4714053       5.5726249       7.6343946
         aic |  5843.4479       5844.8473       5846.3321       5847.7535
         bic |  5862.1563       5868.2327       5874.3946        5880.493
-------------------------------------------------------------------------------
                                          legend: * p<.1; ** p<.05; *** p<.01

. est table arima21*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)

-------------------------------------------------------------------------------
    Variable |   arima211        arima212        arima213        arima214
-------------+-----------------------------------------------------------------
y            |
       _cons | -.11399264      -.11299023      -.11518755        -.114745
-------------+-----------------------------------------------------------------
ARMA         |
          ar |
         L1. |  .26006773       1.1957056***    .39680958***    .29779715***
         L2. |  .03927244      -.91443628***   -.83492246***   -.89274399***
             |
          ma |
         L1. | -.29537225      -1.2256874***   -.43709178***   -.33588403***
         L2. |                  .97207404***    .86844397***     .9442071***
         L3. |                                  .02125732       .00060118
         L4. |                                                  .05136959*
-------------+-----------------------------------------------------------------
sigma        |
       _cons |  9.5398841***     9.450655***    9.4808276***     9.473342***
-------------+-----------------------------------------------------------------
Statistics   |
           N |        794             794             794             794
          ll | -2917.4896      -2910.3454      -2912.6217      -2912.0146
        chi2 |  2.8388146       6763.0586       566.77521       690.44183
         aic |  5844.9792       5832.6907       5839.2433       5840.0292
         bic |  5868.3646       5860.7532       5871.9829       5877.4458
-------------------------------------------------------------------------------
                                          legend: * p<.1; ** p<.05; *** p<.01

. est table arima31*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)

-------------------------------------------------------------------------------
    Variable |   arima311        arima312        arima313        arima314
-------------+-----------------------------------------------------------------
y            |
       _cons | -.11395314      -.11434855      -.11482471      -.11489771
-------------+-----------------------------------------------------------------
ARMA         |
          ar |
         L1. |  .06416111       1.3204613***    -.5619286***    .01972589
         L2. |  .02920804      -.90163025***   -.42025289***   -.77499053***
         L3. |  .02294871      -.05791248**    -.83389309***   -.25249026
             |
          ma |
         L1. | -.10003354      -1.3735497       .51793334      -.05826621
         L2. |                  1.0000008       .40777623       .81652449***
         L3. |                                  .88983828       .26256084
         L4. |                                                  .05469308*
-------------+-----------------------------------------------------------------
sigma        |
       _cons |  9.5380895***    9.4185571       9.4577901       9.4722994***
-------------+-----------------------------------------------------------------
Statistics   |
           N |        794             794             794             794
          ll | -2917.3418      -2909.7635      -2911.5297      -2911.9403
        chi2 |  3.8262796        32923.58       7392.6354       480.87614
         aic |  5846.6836       5833.5271       5839.0595       5841.8806
         bic |  5874.7461       5866.2666       5876.4761       5883.9743
-------------------------------------------------------------------------------
                                          legend: * p<.1; ** p<.05; *** p<.01

. est table arima41*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)

-------------------------------------------------------------------------------
    Variable |   arima411        arima412        arima413        arima414
-------------+-----------------------------------------------------------------
y            |
```

```
       _cons | -.11336618      -.11461152      -.11590868      -.11376705
-------------+------------------------------------------------------------
ARMA         |
          ar |
         L1. | -.26142231        .3181852***    1.7676402***   -.41944632***
         L2. |  .01694481      -.85050807***   -1.5054804*      .36718541***
         L3. |  .03124469       .00130972       .41843749      -.35522863***
         L4. |   .0307881       .04773204        .0005867      -.86090936***
             |
          ma |
         L1. |  .22521179      -.35750674***   -1.8167695***    .38743681***
         L2. |                  .90090477***    1.6207452*     -.30501342***
         L3. |                                 -.49952575       .42560261***
         L4. |                                                   .8658178***
-------------+------------------------------------------------------------
sigma        |
       _cons |  9.5350812***    9.4739792***    9.4436415***    9.4058783***
-------------+------------------------------------------------------------
Statistics   |
           N |        794             794             794             794
          ll | -2917.0927      -2912.0811      -2909.6096      -2906.4848
        chi2 |  5.4882963       661.06102       4207.3335       932.73412
         aic |  5848.1853       5840.1622       5837.2193       5832.9696
         bic |  5880.9249       5877.5789        5879.313       5879.7404
------------------------------------------------------------------------------
                                       legend: * p<.1; ** p<.05; *** p<.01

.
```

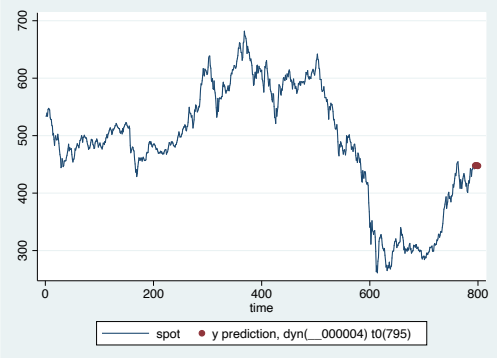
for the future arima(2,1,2) is the most appropriate model since it has the lowest BIC

2.) Make dynamic forecast for period time = 796 to 800.

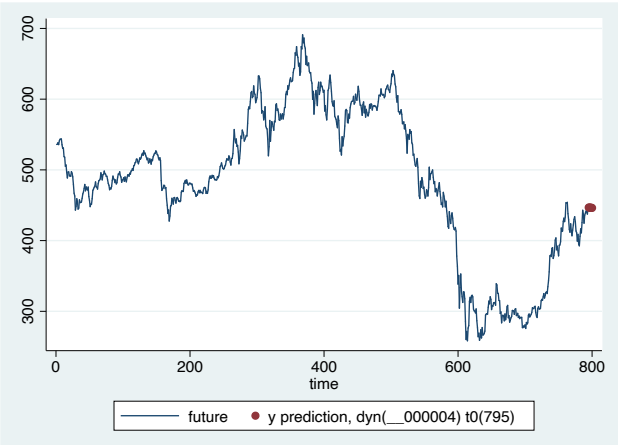
dynamic forecast from 796 to 800

```
. arima spot, arima(1,1,1) nolog

ARIMA regression

Sample:  2 - 795                                Number of obs     =        794
                                                Wald chi2(2)      =      18.31
Log likelihood = -2791.496                      Prob > chi2       =     0.0001

------------------------------------------------------------------------------
             |                 OPG
      D.spot |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
spot         |
       _cons |  -.1047174   .3525647    -0.30   0.766    -.7957316    .5862967
-------------+----------------------------------------------------------------
ARMA         |
          ar |
         L1. |   .4353655   .2343856     1.86   0.063    -.0240219    .8947528
             |
          ma |
         L1. |  -.3535108    .242659    -1.46   0.145    -.8291138    .1220922
-------------+----------------------------------------------------------------
      /sigma |   8.139999   .1507405    54.00   0.000     7.844553    8.435444
------------------------------------------------------------------------------
Note: The test of the variance against zero is one sided, and the two-sided
      confidence interval is truncated at zero.

. set obs 800
number of observations (_N) was 795, now 800

. replace time=_n
(5 real changes made)

. predict spothat, y dynamic(.) t0(795)
Note: beginning dynamic predictions in period
(794 missing values generated)
```

```
. twoway(line spot time ,sort) (scatter spothat time,sort)
```




```
. arima future, arima(2,1,2) nolog

ARIMA regression

Sample:  2 - 795                                Number of obs     =        794
                                                Wald chi2(4)      =    6763.06
Log likelihood = -2910.345                      Prob > chi2       =     0.0000

------------------------------------------------------------------------------
             |                 OPG
  D.future   |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
future       |
       _cons |  -.1129902   .3496789    -0.32   0.747    -.7983483    .5723678
-------------+----------------------------------------------------------------
ARMA         |
          ar |
          L1.|   1.195706   .0266001    44.95   0.000      1.14357    1.247841
          L2.|  -.9144363   .0262076   -34.89   0.000    -.9658023   -.8630703
             |
          ma |
          L1.|  -1.225687   .0174538   -70.22   0.000    -1.259896   -1.191479
          L2.|    .972074   .0174447    55.72   0.000      .937883    1.006265
-------------+----------------------------------------------------------------
       /sigma|   9.450655   .1666509    56.71   0.000     9.124025    9.777285
------------------------------------------------------------------------------
Note: The test of the variance against zero is one sided, and the two-sided
      confidence interval is truncated at zero.

.
. predict futurehat, y dynamic(.) t0(795)
Note: beginning dynamic predictions in period        6.
(794 missing values generated)

. twoway(line future time ,sort) (scatter futurehat time,sort)
```



Part2

3.)Estimate model (1) using OLS by employing future return (rfuture) as dependent variable and spot return (rspot) as explanatory variable, and determine whether ARCH-effect significantly occurs.

```
gen rspot = spot-l.spot
(6 missing values generated)

. gen rfuture = future - l.future
(6 missing values generated)

. replace rspot = rspot/spot
(793 real changes made)

. replace rfuture = rfuture/future
(792 real changes made)

. reg rfuture rspot

      Source |       SS           df       MS      Number of obs   =       794
-------------+----------------------------------   F(1, 792)       =   6161.14
       Model |    .3430572         1    .3430572   Prob > F        =    0.0000
    Residual |  .044099197       792  .000055681   R-squared       =    0.8861
-------------+----------------------------------   Adj R-squared   =    0.8860
       Total |  .387156397       793  .000488217   Root MSE        =    .00746

------------------------------------------------------------------------------
     rfuture |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       rspot |   1.103312   .0140562    78.49   0.000      1.07572    1.130904
       _cons |  -.0000445   .0002649    -0.17   0.866    -.0005645    .0004754
------------------------------------------------------------------------------

. estat archlm
LM test for autoregressive conditional heteroskedasticity (ARCH)
-----------------------------------------------------------------------------
    lags(p)  |          chi2               df                 Prob > chi2
-------------+---------------------------------------------------------------
       1     |         34.112              1                   0.0000
-----------------------------------------------------------------------------
         H0: no ARCH effects      vs.  H1: ARCH(p) disturbance
```

Reject H0: then, we have arch effect in the model

3.)Estimate GARCH(p,q) for future return (rfuture) using spot return (rspot) as explanatory variable for mean equation (model (1) and (2)) – determine the most appropriated order p and q for variance equation using SBIC given the maximum lag equals to 2.

```
do "/Users/jharit/Desktop/garch do file.do"

. forvalues p = 1(1)2{
  2. forvalues q = 1(1)2{
  3.                 display " estimate garch`p'`q'"
  4.                 qui arch rfuture rspot, arch(1/`p') garch(1/`q') nolog
  5.                 est store garch`p'`q'
  6. }
  7. }
 estimate garch11
 estimate garch12
 estimate garch21
 estimate garch22

.
end of do-file

. est table garch* , star(0.1 0.05 0.01) stat(N ll chi2 aic bic)

-------------------------------------------------------------------------------
    Variable |    garch11         garch12         garch21         garch22
-------------+-----------------------------------------------------------------
rfuture      |
       rspot |  1.0645681***     1.064238***    1.0682047***    1.0680005***
       _cons | -.00004419      -.00005155      -.00006558      -.00006707
-------------+-----------------------------------------------------------------
ARCH         |
        arch |
         L1. |  .08508817***    .11662409***    .22294495***    .22541563***
         L2. |                                 -.16183182***   -.18077526***
             |
       garch |
         L1. |  .89766172***    .51492192       .92480421***    1.1004611***
         L2. |                  .34282779                       -.15477774
             |
       _cons |  9.520e-07***    1.374e-06**     7.402e-07***    5.126e-07**
-------------+-----------------------------------------------------------------
Statistics   |
           N |        794             794             794             794
          ll |  2853.3906        2854.746       2858.4282       2858.8165
        chi2 |  13442.953       12918.945       12438.335       12846.434
         aic | -5696.7811       -5697.492      -5704.8564       -5703.633
         bic | -5673.3957      -5669.4295      -5676.7939      -5670.8934
-------------------------------------------------------------------------------
                                        legend: * p<.1; ** p<.05; *** p<.01

.
```

Garch(1,2) is the most appropriated one since it has the lowest bic

5.) From (4), predict the variance of future return (rfuture).

```
arch rfuture rspot, arch(1/2) garch(1) nolog

ARCH family regression

Sample: 2 - 795                                 Number of obs   =        794
Distribution: Gaussian                          Wald chi2(1)    =   12438.33
Log likelihood =  2858.428                      Prob > chi2     =     0.0000

------------------------------------------------------------------------------
             |                 OPG
     rfuture |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rfuture      |
       rspot |   1.068205    .009578   111.53   0.000     1.049432    1.086977
       _cons |  -.0000656   .0001916    -0.34   0.732     -.000441    .0003099
-------------+----------------------------------------------------------------
ARCH         |
        arch |
         L1. |   .2229449   .0531304     4.20   0.000     .1188113    .3270786
         L2. |  -.1618318   .0538085    -3.01   0.003    -.2672946   -.0563691
             |
       garch |
         L1. |   .9248042   .0140053    66.03   0.000     .8973544    .9522541
             |
       _cons |   7.40e-07   2.32e-07     3.19   0.001     2.85e-07    1.20e-06
------------------------------------------------------------------------------

. predict sigma2 , v

. line sigma2 time
```